Translation of EP 0518907 B1

Title: Method for monitoring the quality during the milking of animals

Description

The invention concerns a method of the type described in the introductory part of claim 1.

It is known that the electrical conductivity of milk from cows and other animals changes value in the case of inflammations of glands in the teat area in relation to the healthy state of the animal. In the case of an inflammation, an increased electrical conductivity is apparent. The early recognition of such an inflammation (mastitis) is of great importance in cows since suitable countermeasures can be taken before the inflammation becomes visible and because, on the other hand, the milk originating from inflamed glands have a higher content of dangerous germs. Milk originating from teats that have contracted mastitis differs from the milk from healthy teats through increased electrical conductivity.

The conductivity value signal obtained from a conductivity measurement cell arranged in the flow path of the milk from a teat is a signal with a high noise level. Particularly in the event of insufficient milk yield, high signal variations occur which do not permit a useful conductivity measurement. Another difficulty is that the conductivity of the milk is subject to variations of a seasonal nature and which also depend on other factors such as the composition of the feed. Due to the problems mentioned, early recognition of teat diseases by means of the electrical conductivity of the extracted milk in a on-line method, i.e. immediately at the extraction of the milk from the animal, has only been possible with considerable uncertainties.

Such a method is also known from US-A-3.989.009. In this method, milk in test tubes is brought to an apparatus with which a signal generator is associated. The signals sent out from the signal generator are modified by virtue of the different conductivity of the milk in the individual tubes. Evaluation means for the conductivity signals are connected after the apparatus.

From EP-A-0 222 612 it is known for the analysis of chromatographic data to make the signals obtained through conductivity measurements more clear and better distinguishable by means of a filter.

A method with the features stated in the introductory part of claim 1 is also known from US-A-4.325.028. In this, the smallest conductivity signal is determined from the conductivity signals associated with the individual teat areas, and in a comparison circuit the conductivity signals of the milk from the other teat areas are compared with the smallest conductivity signal, whereby the difference is generated in each case. The individual differences are each compared with a predetermined upper and lower threshold value. Furthermore, it is determined whether the smallest conductivity signal lies above a further upper threshold value. The processing of the conductivity signals is made analog without a frequency filtering being provided. Also, only those conductivity signals that appear simultaneously during a milking procedure are compared with one another.

US-A-4.225.820 describes a method by which the conductivity signals from the milk in the individual teat cups are each only compared with an upper threshold value. A display means shows whether this threshold value is exceeded by the milk from an individual teat.

Furthermore, US-A-4.793.285 describes a method for monitoring the quality during the milking of animals. In this method, the conductivity measurement signals obtained are introduced into an analog-digital converter. A comparison between each of the determined, individual conductivity signals is, however, not provided.

The task of the invention is to provide a method of the type stated in the introductory part of claim 1 and which enables a certain recognition of gland inflammations in a teat immediately upon milk extraction.

According to the invention, the solution to this task comprises the features stated in claim 1.

According to the invention, the conductivity signals from the individual measuring cells, each of which is associated with a teat cup, are first subjected to a digital filtering with a signal processor whereby signal frequencies above 0.2 Hz are suppressed. An analog-operating low-pass filter with such a low cut-off frequency cannot be realised or only with great effort. The digital signal processor is then used to filter off the higher-frequency noise signals, said signal processor carrying out a spectral analysis of the electrical signals fed to it, for example a fast-fourier-transformation. In this manner, a low-pass filtering with a very low upper cut-off frequency can be carried out with simple technical means. The upper cut-off frequency must not necessarily be 0.2 Hz; it could also be lower, for example 0.1 Hz.

The conductivity signals filtered in this manner, which do not contain the higher frequency noise component any longer, are compared with one another from measuring cell to measuring cell so that deviations caused by disease in individual teats can easily be determined. Preferably, a teat is recognised as sick when the filtered conductivity signal of the milk delivered by it lies a predetermined (adjustable) percentage above the conductivity signals of the milk delivered by the other teats. In order to include the case where several teats are sick, the individual comparison can be made with the conductivity value from the milk delivered by those teats whose milk have the lowest conductivity value.

For each teat cup, the milking procedure is divided into time intervals which each have a predetermined duration. Thus, the entire milking process consists of numerous mutually equal time intervals which are numbered continuously. In each time interval, a characteristic conductivity value is determined which is evaluated and stored. The characteristic conductivity value is preferably the determinable peak value which has occurred in the interval in question, but another value, for example the mean value for this interval, can also be used as characteristic value.

In the various phases of the milking procedure, which consists of the pre-milking, the main milking and the post-milking, different conductivity values normally occur. The milking procedures of the individual teats are thereby shifted in relation to one another because the teat cups are put sequentially on to the teats. By virtue of the fact that an individual interval sequence is associated with each teat cup,

those intervals within the milking procedure corresponding to one another can be compared with one another, even though these intervals are shifted in time in relation to one another. The characteristic conductivity values compared are those for those intervals whose numbers are the same.

Each of the milking procedures which are carried out in the morning and in the evening, day after day, can differ from other milking procedures over several days. For an analysis of the health condition of the udder of the animal, it can be appropriate to compare the milking procedures to one another over a longer period in order to detect normal trends or abnormal increases in the milk conductivity value. Generally, differences in conductivity value of 1000 μS/cm within 3 days occur.

The method according to the invention permits storing the characteristic conductivity values of the numerous intervals within a milking procedure and compare them with the characteristic conductivity values of several previous milking procedures. The suspicion of the subclinical milking procedure should always be made when the differential conductivity within a few milking procedures jump upwards by some hundreds of micro-Siemens. In that connection the absolute level of the conductivity value is insignificant. The classical case of subclinical mastitis consists in that milk is delivered from one teat with a conductivity value which is 1000 or 2000 μS higher than that of the milk from the three other teats.

When the conductivity of the milk from the tree healthy teats lies within a deviation range of about 200 to 400 μS, then this can be considered normal. The conductivity of a diseased teat will, however, regularly deviate by more than 1000 μS upwards.

Towards the end of the milking procedure, the conductivity of the milk drops due to the increasing fat content in the post-milk (stripping). By comparison of the conductivity measurement curve of the entire milking procedure with a reference curve, an abnormal process can be detected.

It is typical that the pre-milking exhibits a higher conductivity value due to the high tendency to germ contamination within the first seconds of the milking procedure,

and then quickly drops off and assumes a lower value during the main milking of a healthy cow, which lower value can change continually. Through the comparison of the pre-milking between the individual teats and through comparison means of the current pre-milking with one or more earlier pre-milkings from the same teat, it can be determined with a high degree of certainty whether significant deviations are present.

According to a further development of the invention, a further filtering of the conductivity signals is carried out by suppressing amplitude values which deviate more than a predetermined extent from previous amplitude values of the same measuring cell. Thereby, it is ensured that outliers do not falsify the measuring result. The predetermined degree is suitably determined as a fraction or percentage of the earlier amplitude value, the latter preferably being the last measured amplitude value from the same measuring cell.

Since the determination is carried out on-line, it is possible in the method of the invention to sequester milk delivered by a diseased teat prior to introduction into the milk tank. In this manner, it is ensured that milk containing germs is not mixed with healthy milk.

In the following, a working example of the invention is explained in more detail with reference to the drawings.

In the drawings:

figure 1	shows a schematic illustration of the milk flow from a teat cup until a milk tank,
figure 2	shows a schematic illustration of the measuring chamber containing the conductivity measurement cell,
figure 3	is a block diagram of the evaluation means,
figure 4	shows characteristic time curves of the conductivity signal during a milking procedure,
figure 5	shows obtaining the characteristic conductivity signals, and
figure 6	shows the time curve of the conductivity in a teat in which a progressing disease has been determined over several days.

In figure 1, the teat cup 10 is shown of a milking machine having four such teat cups. The teat cup 10 is put onto the teat of a cow in a known manner. At the outlet of the teat cup 10, a flow measurement means 11 is located, and from this a conduit leads into the measuring chamber 12. From the measuring chamber 12, the milk flows via a magnetically controlled valve 13 into the milk collector 14. In the milk collector 14, milk flows from all four teat cups are combined. The milk collector is connected to a periodically operating suction pump 15 as well as to a tank 16 in which the milk is collected.

From the valve 13, a branch conduit 17 leads into a collector 18 for lower-grade milk. As long as healthy milk is measured in the measuring chamber 12, the valve 13 is switched to the milk collector 14, whereas it is switched over to the collector 18 when germ-containing milk is determined in the associated measuring chamber 12 by means of a too high conductivity value.

The measuring chamber 12 is shown schematically in figure 2. It has a housing 19 with an inlet 20 in the lid and an outlet 21 at the bottom. In the housing 19, a capturing container 22 is located under the inlet 20, in which container the milk from inlet 20 falls down. In the capturing container 22, the measurement cell 23 is arranged which consists of an excitation coil 24 and a receiver coil 25 or secondary coil coaxial therewith. The two coils 24 and 25 form a coreless transformer. The excitation coil 24 is supplied with an excitation frequency of about 5 to 10 kHz from an oscillator 26. Depending on the conductivity value of the milk located inside the coils, a voltage will be generated at the receiver coil 25 and be amplified by means of an amplifier 27. This voltage constitutes the conductivity signal.

For automatic identification of the cow, it is supplied with a corresponding machine readable coding. Thereby, it is obtained that conductivity values are always associated with the same cow and are stored in storage areas provided for this cow. Finally, care must be taken that an unambiguous association between the teat cups and teats of the cow is present, i.e. that the same teat cup is put on to the same teat every time.

According to figure 3, the conductivity signal delivered by the measuring cell 23 is led to a multiplexer 28 which furthermore receives the conductivity signals from the measuring cells associated with three other teat cups and delivers the four conductivity signals in a time multiplex mode to an analog/digital converter 29. The conductivity signals are processed in digital form in the digital signal processor (DSP) 30. The signal processor conducts a fast-fourier-analysis and a low-pass filtering or band filtering whereby frequencies between 0,01 and 0,1 Hz are allowed through, and all other frequencies are suppressed. Furthermore, an amplitude filtering is carried out in the signal processor 30 whereby those amplitude values which deviate more than a predetermined degree (15%) downwards from earlier amplitude values from the same measuring cell are suppressed.

The filtered conductivity signals which constitute representative results for the yet to be determined intervals of a milking procedure are stored in a table in the RAM memory 31. Furthermore, the output signals from the signal processor 30 are input to a further processor 32 in which they are compared with signals stored in the memory 31, i.e. with conductivity signals from earlier milking procedures.

Upon recognition of milk from a diseased teat, the output 33 from the processor 32 will provide a signal to an alarm means 34 as well as to the magnet 13a of the magnetic valve 13 (figure 1) so that this valve is switched to the collector 18.

An input/output means 25 is furthermore connected to the processor 32 through which the conductivity values of the current milking procedure can be shown graphically on a monitor along with the conductivity values from earlier milking procedures recalled from the memory 31. Furthermore, the output means 35 contains a keyboard by means of which the threshold values and permissible fractions (percentages) for the filtering and evaluation of the conductivity value signals can be adjusted.

Furthermore, the processor 32 receives the signal from the flow measuring means 11 which measures the amount of milk delivered. If milk flows only very sparingly from a teat, a report signal is also generated. This function of the flow monitoring can also stop the milking procedure when the signal is given to the suction pump 15.

The digital signal processor 30 effects the filtering out of the useful conductivity signals as well as the processing of these signals into a characteristic signal for each interval. The processor 32, however, carries out the administration and evaluation of the processed characteristic conductivity values.

In figure 4, the time course of a typical milking procedure is shown whereby the specific conductivity value k in μS/cm is shown on the vertical axis. "Conductivity value" always means the specific electrical conductivity value.

The milking procedure consists of the phases pre-milking VG, main milking HG and post-milking (stripping) NG. Reference number 36 indicates the typical time course of the conductivity value of milk from a healthy teat. It will be seen that the conductivity value is subject to strong variations and full of noise which can be attributed in particular to the influence of the suction pulses of the suction pump 15 (figure 1) that are active in the measuring chamber.

Reference number 37 designates the smooth course of the conductivity value curve of milk from a diseased teat. The conductivity values are about 1000 μS/cm above the curve 36.

The acquisition of the characteristic conductivity values destined for the evaluation is explained by means of figure 5.

The entire milking procedure is divided into numerous intervals each of a duration of 6 seconds, said intervals being indicated in figure 5 along the time axis t and being numbered sequentially. In each of these intervals, a characteristic conductivity value is determined which is marked by means of a point. In the working example shown, the characteristic conductivity value is the peak value in the interval in question, i.e. the amplitude of a signal peak.

Those frequencies which lie outside the band pass region of the digital frequency filter are suppressed. For example, the curve 36 in figure 5 contains an unusual region 38 of high frequency and high amplitude variation. This region 38 is suppressed. In this region, no generation of a characteristic conductivity value

destined for evaluation will be carried out. Through the filtering, no smoothing of the unwanted signal area is carried out; instead, it is not taken into account during the evaluation.

The digital signal processor 30 delivers the characteristic conductivity values, which are marked by means of points in figure 5 and designated 39, along with the accompanying interval numbers to the processor 32 and the memory 31. In the memory 31, the entire milking procedure, separated according to teat cups, is documented whereby all characteristic conductivity values 39 along with their interval numbers are stored in a table for each teat cup.

The processor 32 compares the characteristic conductivity values of the four teat cups with one another, interval by interval, in order to be able to determine a curve from a teat deviating from the other curves, and it also compares the curves of the current milking procedure with the stored curves from earlier milking procedures, separated according to each teat, whereby the intervals are associated with one another.

Figure 6 shows the conductivity value k over time whereby the time is indicated in days. Reference number 40 designates the curve of a healthy teat, and reference number 41 designates the curve of a diseased teat. Each of the curves 40 and 41 consists of points, each of which constitutes a characteristic value of a milking procedure, for example the mean value of all characteristic values 39. Disease in a teat is then determined when the value of the curve 41 deviates by a certain percentage (15%) from the earlier values of the same teat. In this case, the diseased teat is still in the early stages of the disease.